



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁴ : C03C 13/00, 13/02, 25/06	A2	(11) International Publication Number: WO 89/12032 (43) International Publication Date: 14 December 1989 (14.12.89)
(21) International Application Number: PCT/US89/02288 (22) International Filing Date: 25 May 1989 (25.05.89) (30) Priority data: 201,513 1 June 1988 (01.06.88) US (71) Applicant: MANVILLE SALES CORPORATION [US/ US]; Manville Plaza, 5th Floor, P.O. Box 5108, Denver, CO 80217 (US). (72) Inventors: OLDS, Leonard, Elmo ; 977 South Lake Gulch Road, Castle Rock, CO 80104 (US). KIELMEYER, Wil- liam, Henry ; 3374 West Chenango Avenue, Englewood, CO 80110 (US). (74) Agent: SCHRAMM, William, J.; Brooks & Kushman, 2000 Town Center, Suite 2000, Southfield, MI 48075 (US).		(81) Designated States: AT (European patent), AU, BE (Euro- pean patent), BR, CH (European patent), DE (European patent), DK, FI, FR (European patent), GB (European patent), IT (European patent), JP, KP, KR, LU (Euro- pean patent), NL (European patent), NO, SE (European patent). Published <i>Without international search report and to be republished upon receipt of that report.</i>
(54) Title: PROCESS FOR DECOMPOSING AN INORGANIC FIBER (57) Abstract Inorganic fibers which have a silicon extraction of greater than 0.02 wt% Si/day in physiological saline solutions. The fiber contains SiO ₂ , MgO, CaO, and at least one of Al ₂ O ₃ , ZrO ₂ , TiO ₂ , B ₂ O ₃ , iron oxides, or mixtures thereof. Also disclosed are inorganic fibers which have diameters of less than 3.5 microns and which pass the ASTM E-119 two hour fire test when processed into a fiber blanket having a bulk density in the range of about 1.5 to 3 pcf.		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FI	Finland	ML	Mali
AU	Australia	FR	France	MR	Mauritania
BB	Barbados	GA	Gabon	MW	Malawi
BE	Belgium	GB	United Kingdom	NL	Netherlands
BF	Burkina Fasso	HU	Hungary	NO	Norway
BG	Bulgaria	IT	Italy	RO	Romania
BJ	Benin	JP	Japan	SD	Sudan
BR	Brazil	KP	Democratic People's Republic of Korea	SE	Sweden
CF	Central African Republic			SN	Senegal
CG	Congo	KR	Republic of Korea	SU	Soviet Union
CH	Switzerland	LI	Liechtenstein	TD	Chad
CM	Cameroon	LK	Sri Lanka	TG	Togo
DE	Germany, Federal Republic of	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		
ES	Spain	MG	Madagascar		

PROCESS FOR DECOMPOSING AN INORGANIC FIBER

FIELD OF INVENTION

5 This invention relates to inorganic fiber compositions and more particularly it relates to inorganic fiber compositions which can contain silica, magnesia, calcium oxide, alumina, and other oxides. Some of the inventive fibers have excellent fire ratings, some have especially low durabilities in physiological saline solutions, and some have combinations of
10 these foregoing properties.

BACKGROUND OF THE INVENTION

For many years, inorganic fibers generically referred to in the industry as "mineral wool fibers", made from slag, rock, fly ash, and other by-product raw materials have been manufactured. These fibers have
15 been typically manufactured by melting the slag, rock, etc., containing such oxides as silica, alumina, iron oxide (ferrous and ferric), calcium oxide, and magnesia; allowing the molten material to be blown by gas or steam or to impinge on rotors at high speeds; and causing the
20 resulting blown or spun fibers to be accumulated on a collecting surface. These fibers are then used in bulk or in the form of mates, blankets, and the like as both low and high temperature insulation. U.S. Patent No. 2,576,312 discloses a conventional mineral wool composition and method for making the same.
25

In the past, the industry has well recognized the standard drawbacks associated with conventional mineral wool fibers. Conventional mineral wool fibers
30 may have high contents of undesired oxides which often

-2-

detract from their refractory properties. The conventional mineral wools are coarse, i.e. they have average fiber diameters of 4 to 5 microns (measured microscopically) and have high shot contents in the range of 30 to 50 weight percent. The coarseness of the fiber reduces the insulating value of the fiber and makes conventional mineral wool unpleasant to handle and unfriendly to the touch. For example, because of their coarse fiber diameters, conventional mineral wool blankets must have bulk densities of from 4 to 8 pcf and even higher in order to pass the ASTM E-119 two hour fire test. On the other hand, fiber glass blankets are often made with bulk densities of 2 pcf or lower. While the fiber glass blankets are friendly because of their low bulk densities and relatively fine fiber diameter, they do not have sufficient fire resistance so as to pass even the one hour ASTM E-119 fire test.

Recently, another potential problem with traditional mineral wool and other types of fiber has been recognized. It is well known that inhalation of certain types of fiber can lead to elevated incidence of respiratory disease, including cancers of the lung and surrounding body tissue. Several occurrences are well-documented in humans for several types of asbestos fiber. Although for other varieties of natural and manmade mineral fiber direct and unequivocal evidence for respiratory disease is lacking, the potential for such occurrence has been inferred from results of tests on laboratory animals. In the absence or insufficiency of direct human epidemiological data, results from fiber inhalation or implantation studies on animals provides the best "baseline information" from which to extrapolate disease potential.

SUBSTITUTE SHEET

-3-

Chronic toxicological studies on animals have, however, been able to statistically demonstrate the importance of three key factors that relate directly to the potential for respiratory disease and especially carcinoma: (a) dose of fiber received (including time of exposure); (b) dimension of the inhaled fiber; and (c) persistence of the fiber within the lung. The effects of dose and dimension have been well-characterized from such studies and as a result are fairly well known in regard to human disease potential. The dose is obviously a product of the environment in which the fiber is used and the manner in which it is used. The dimension and persistence of the fiber within the lung, on the other hand, are functions of the manner in which the fiber is formed and of its chemical composition. In general, the smaller the fiber the more likely that it will become embedded in lung tissue when inhaled, thus increasing the danger of respiratory disease.

Although less is known about the link between persistence of the fiber within the lung and respiratory disease, increasing attention is being focused on this aspect of the health issue. Biological persistence refers to the length of time a fiber endures as an entity within the body. The physiochemical concept that most closely relates to persistence and is perhaps more easily quantified is that of "durability" - specifically, the chemical solubility (or resistance to solubility) of fibers in body fluids and the tendency of such fibers to maintain physical integrity within such an environment. In general, the less durable a fiber is, the less will be the potential health risk associated with the inhalation of that fiber. One method of measuring the chemical durability of a fiber in body fluids is to measure its durability in physiological

SUBSTITUTE SHEET

-4-

saline solutions. This can be done by quantifying the rate of extraction of a chemical component of the fiber such as silicon into the physiological saline solution over a certain period of time.

5 Thus, as can be easily concluded from the foregoing discussion, conventional mineral wool fibers have several serious drawbacks. However, even the alternatives to mineral wools have problems. For example, as mentioned earlier glass fibers have a fire
10 resistance problem and whereas the refractory ceramic fibers have been gaining increasing use in recent years as an alternative to mineral wool fibers because of their ultra-high temperature resistance and superior ability to pass all fire rating tests, their use is
15 limited by the fact that they are relatively expensive and have a relatively high chemical durability in physiological saline solutions as well.

 In conclusion, there is a great need in the industry for low cost, friendly feeling low bulk density
20 inorganic fibers which have good fire resistance properties as measured by their ability to pass the ASTM E-119 two hour fire test. Additionally, there is a tremendous demand for fibers which have especially low durabilities in physiological saline solutions. What would be
25 particularly advantageous to the industry would be fibers with combinations of the above mentioned sought after properties. Also, advantageous would be fibers which also have excellent refractory properties as well, e.g. high continuous service temperatures.

SUBSTITUTE SHEET

-5-

SUMMARY OF THE INVENTION

In one embodiment of the present invention, there are provided inorganic fibers having a silicon extraction of greater than about 0.02 wt% Si/day in physiological saline solutions and a composition consisting essentially of about 0-10 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 35-70 wt% SiO_2 ; 0-50 wt% MgO ; and CaO .

In another embodiment of the present invention, there are provided inorganic fibers which have a 5 hour silicon extraction in physiological saline solutions of at least about 10 ppm. These fibers can broadly have compositions consisting essentially of the following ingredients at the indicated weight percentage levels:

0-1.5 wt% of either Al_3O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 40-70 wt% SiO_2 ; 0-50 wt% MgO ; and CaO

1.5-3 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 40-66 wt% SiO_2 ; 0-50 wt% MgO ; and CaO

3-4 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 40-64 wt% SiO_2 ; 0-50 wt% MgO ; and CaO

4-6 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 40-59 wt% SiO_2 ; 0-25 wt% MgO ; and CaO

6-8 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 35-54 wt% SiO_2 ; 0-25 wt% MgO ; and CaO

8-10 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 35-45 wt% SiO_2 ; 0-20 wt% MgO ; and CaO

SUBSTITUTE SHEET

-6-

In a preferred embodiment, inventive fibers with 5 hour silicon extractions of greater than about 20 ppm and most preferably greater than about 50 ppm are provided.

5 In another embodiment of the present invention there are provided inorganic fibers having a diameter of less than 3.5 microns and which pass the ASTM E-119 two hour fire test when processed into a fiber blanket having a bulk density in the range of about 1.5 to 3 pcf and having a composition consisting essentially of
10 about: 0-10 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures thereof; 58-70 wt% SiO_2 ; 0-21 wt% MgO ; 0-2 wt% alkali metal oxides; and CaO and wherein the amount of alumina + zirconia is less than 6 wt% and
15 the amount of iron oxides or alumina + iron oxides is less than 2 wt%. Preferably, the inventive fibers in this embodiment may have compositions consisting essentially of about:

0-1.5 wt% of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron
20 oxides, or mixtures thereof; 58.5-70 wt% SiO_2 ; 0-21 wt% MgO ; 0-2 wt% alkali metal oxides; and CaO

greater than 1.5 wt% up to and including 3 wt%
of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures
thereof; 58.5-66 wt% SiO_2 ; 0-21 wt% MgO ; 0-2 wt% alkali
25 metal oxides; and CaO

greater than 3 wt% up to and including 4 wt%
of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures
thereof; 58-63 wt% SiO_2 ; 0-8 wt% MgO ; 0-2 wt% alkali
metal oxides; and CaO

30 greater than 4 wt% up to and including 6 wt%
of either Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides, or mixtures
thereof; 58-59 wt% SiO_2 ; 0-7 wt% MgO ; 0-2% alkali metal
oxides; and CaO .

SUBSTITUTE SHEET

-7-

As discussed herein earlier, there has been a demand in the industry for inorganic fibers with an excellent fire rating at low bulk densities and fibers with especially low chemical durabilities in physiological saline solutions. Therefore, each category of inventive fibers should fulfill a real need in the industry and should be available for applications where heretofore low cost, mineral wool type fibers have not been available. What is particularly advantageous about the present invention is the fact that fibers are provided where a special demand exists, i.e. applications in the industry where fibers with both an excellent fire rating and an especially low durability in physiological saline solutions are in demand.

Other features and aspects, as well as the various benefits and advantages, of the present invention will be made clear in the more detailed description which follows.

DETAILED DESCRIPTION OF THE INVENTION

The inventive fiber compositions of the present invention can be made from either pure metal oxides or less pure raw materials which contain the desired metal oxides. Table 1 herein gives an analysis of some of the various raw materials which can be used to make inventive fiber compositions. Physical variables of the raw materials such as particle size may be chosen on the basis of cost, handleability, and similar considerations.

Except for melting, the inventive fibers are formed in conventional inorganic fiber forming equipment

SUBSTITUTE SHEET

-8-

and by using standard inorganic fiber forming techniques as known to those skilled in the art. Preferably, production will entail electric furnace melting rather than cupola melting since electric melting keeps molten
5 oxides of either pure or less pure raw materials more fully oxidized thereby producing longer fibers and stronger products. The various pure oxides or less pure raw materials are granulated to a size commonly used for electric melting or they may be purchased already so
10 granulated.

The granulated raw materials are then mixed together and fed to an electric furnace where they are melted by electric resistance melting with electrodes preferably positioned according to the teachings of U.S.
15 Patent No. 4,351,054. Melt formation can be either continuous or batchwise although the former is preferred. The molten mixture of oxides is then fiberized as disclosed in U.S. Patent No. 4,238,213.

While the fiberization techniques taught in
20 U.S. 4,238,213 are preferred for making the inventive fibers, other conventional methods may be employed such as sol-gel processes and extrusion through holes in precious metal alloy baskets.

The fibers so formed will have lengths in the
25 range of from about 0.5 to 20 cm and diameters in the range of from about 0.05 to 10 microns with the average fiber diameter being in the range of about 1.5 to 3.5 microns. Table 2 shows the average fiber diameter (measured microscopically) and the unfiberized shot
30 content of various inventive fibers. As may be seen, the average microscopic fiber diameter was 2.3 microns and the average unfiberized shot content was 27%.

SUBSTITUTE SHEET

-9-

For purposes of comparison, conventional mineral wool fibers were also tested with the results being given in Table 2 as numbers 226 and 229. These conventional fibers averaged 4.7 microns (measured microscopically) in diameter and had an average 40 wt% shot content. The continuous service temperature ranged from 1370°F to 1490°F, averaging 1420°F.

Table 3 contains an extensive chemical analysis of a number of inventive fibers. Because of the large number of fiber samples containing alumina additives made to the base calcium oxide/magnesia/silica system, only the average analysis of the minor constituent of these fibers are given in Table 3. The silica, alumina, magnesia, and calcium oxide contents for these fibers are given in Table 4.

As used herein, the "service temperature" of an inorganic fiber is determined by two parameters. The first is the obvious condition that the fiber must not soften or sinter at the temperature specified. It is this criterion which precludes the use of glass fibers at temperatures about 800°F to 1000°F (425° to 540°C). Additionally, a felt or blanket made from the fibers must not have excessive shrinkage when soaking at its service temperature. "Excess shrinkage" is usually defined to be a maximum of 5% linear or bulk shrinkage after prolonged exposure (usually for 24 hours) at the service temperature. Shrinkage of mats or blankets used as furnace liners and the like is of course a critical feature, for when the mats or blankets shrink they open fissures between them through which the heat can flow, thus defeating the purpose of the insulation. Thus, a fiber rated as a "1500°F (815°C) fiber" would be defined

SUBSTITUTE SHEET

-10-

as one which does not soften or sinter and which has acceptable shrinkage at that temperature, but which begins to suffer in one or more of the standard parameters at temperatures above 1500°F (815°C).

5 The service temperatures for a representative number of fibers in the inventive compositional range are listed in Table 2. The continuous service temperature for constant silica/magnesia/calcium oxide ratios are given in Table 6. As may be seen in all cases, the
10 lower the alumina content of the fiber, the higher the service temperature will be, with the highest service temperature being at zero percent alumina for alumina contents less than 30%. Thus to attain the most desired properties of the inventive fiber it is not possible to
15 accept any of the alumina contents resulting from melting the traditional mineral wool raw materials. Rather, various amounts of sufficiently pure oxides will be required to dilute the alumina contents to the desired low levels. To attain fibers of the highest
20 service temperatures, only pure raw materials with essentially no significant amounts of alumina must be used.

 A series of inventive fibers were also tested for their silicon extraction in a saline solution
25 according to the following procedure:

 A buffered model physiological saline solution was prepared by adding to 6 liters of distilled water the following ingredients at the indicated concentrations:

30	<u>Ingredient</u>	<u>Concentration, g/l</u>
	MgCl ₂ ·6H ₂ O	0.160
	NaCl	6.171

SUBSTITUTE SHEET

-11-

	KCl	0.311
	Na ₂ HPO ₄	0.149
	Na ₂ SO ₄	0.079
	CaCl ₂ ·2H ₂ O	0.060
5	NaHCO ₃	1.942
	NaC ₂ H ₃ O ₂	1.066

Before testing, this solution was buffered to a pH of 7.6 by bubbling with a gaseous mixture of 5% CO₂/95%N₂.

10 One half (1/2) gram of each sample of fiber listed in Table 3 was then placed into separate closed, plastic bottles along with 50 cc of the prepared physiological saline solution and put into an ultrasonic bath for 5 hours. The ultrasonic vibration application was
15 adjusted to give a temperature of 104°F at the end of the 5 hour period. At the end of the test period, the saline solution was filtered and the solution chemically analyzed for silicon content. The silicon concentration
20 in the saline solution was taken to be a measure of the amount of fiber which solubilized during the 5 hour test period. The CaO and MgO contents of the fiber were similarly solubilized.

 One of the inventive fibers was tested for silicon extraction in a physiological saline solution
25 for periods of up to 6 months. Results were as follows:

SUBSTITUTE SHEET

-12-

Fiber Number	Steady State		Total Amphoteric Oxides in Fiber	Comments On Fiber Residue After 6 Months
	Silicon Extraction in 6 Months	Silicon Extraction Rate For 0.20 m ² /g Surface Area, % Si/day		
29 (inventive)	96%	0.16%	1.0%	carbonate hydroxyl apatite fiber, disintegrated into small particles
137 (non- inventive)	3%	0.013%	8.9%	slight fine grained fibers with uniform corrosion
235 (non- inventive)	4%	0.012%	25.6%	no fiber corrosion; some surface deposition

SUBSTITUTE SHEET

-13-

Categorization of oxides melts according to scales of acidity or basicity has been well known for many years. (See "A Scale of Acidity and Basicity in Glass," Glass Industry, February 1948, pp 73-74.) We have now found that by strictly controlling the compositions of the oxide melts according to the acidic or basicity behavior of the respective oxides, fibers can be made which are surprisingly soluble in saline solutions. Increasing the content of silica, alumina, and the amphoteric oxides in the fiber increases the acid ratio of the fiber composition. This tends to stabilize the system against silicon extraction by weak solutions as a result of relative changes in the interatomic bonding forces and extension of the silica network. Other amphoteric oxides besides alumina will have an alumina equivalency with respect to extraction by saline solutions. The amphoteric oxides zirconia and titania appear to have an alumina equivalency of close to 1 to 1. We have found that in general for desired high saline solubility the amount of total amphoteric oxides must be kept below about 10% depending upon the amount of silica present. On the other hand, with the exception of iron and manganese oxides, the basic oxides can vary widely since their alumina equivalency is small. However, while iron and manganese oxides are generally considered to be basic in nature, their behavior with respect to saline solubility more closely relate to the amphoteric oxides, thus the amounts of iron and manganese oxides must be similarly limited.

Many of the fibers were tested for their fire resistance according to the following simulated fire rating test procedure:

SUBSTITUTE SHEET

-14-

For screening test purposes, a small furnace was constructed using an electrically heated flat-plate element at the back of the heat source. A 6 inch x 6 inch x 2 inch thick sample of 1 3/4 to 6 1/2 pcf density of each formulated fiber was mounted parallel with the element and 1 inch from it. Thermocouples were then positioned at the center of the fiber sample surfaces. A computer was used to control power via a simple on-off relay system to the heating element. The position of the relay was based on the reading of the thermocouple on the sample surface nearest the element and the programmed fire test heat-up schedule.

The furnace was heated so as to follow a standard ASTM E-119 time/temperature curve for the 2-hour test period. In the test utilized herein, failure of the fiber is considered to occur when the furnace is unable to maintain the standard temperature per ASTM E-119 because the fiber insulation has sintered sufficiently to allow heat to escape through the fiber layer.

The results of the testing of the fibers for saline solubility and the two hour ASTM E-119 fire test are given in Table 4 for the fibers made with alumina addition and in Table 5 for the remaining fibers to which other oxidic constituents were added. These additions included: B_2O_3 , P_2O_5 , TiO_2 , ZrO_2 , Fe_2O_3 + MnO , La_2O_3 , Cr_2O_3 , and Na_2O . For glass fibers within the scope of the invention to function in an ASTM E-119 fire test, i.e. to withstand the rising temperatures of a simulated fire which can reach 1850°F in two hours, it is necessary that they convert from an amorphous condition to a beneficial pseudo crystalline state during heat-up. The inventive fibers do this but can be assisted in this function by the inclusion of suitable crystal nucleating

SUBSTITUTE SHEET

-15-

agents. Such agents may include TiO_2 , ZrO_2 , platinum, Cr_2O_3 , P_2O_5 , and others. Such additions are within the scope of this invention.

SUBSTITUTE SHEET

TABLE 1
RAW MATERIALS USED

Pure Raw Materials					
	<u>Silica Sand</u>	<u>Quick Lime</u>	<u>Calcined Dolomite</u>	<u>Aluminum Oxide</u>	<u>Magnesium Oxide</u>
<u>ACIDIC OXIDES</u>					
SiO ₂	99.0	0.34	0.50	0.02	0.4
<u>AMPHOTERIC OXIDES</u>					
TiO ₂	nil	nil	nil	0.002	nil
Al ₂ O ₃	0.30	0.26	0.50	98.8	0.1
<u>BASIC OXIDES</u>					
Fe ₂ O ₃	0.30	0.05	0.15	0.02	0.7
MnO	--	--	--	--	--
MgO	0.02	0.14	40.0	nil	96.3
CaO	0.03	97.75	57.0	0.01	2.0
Na ₂ O	0.04	0.02	0.01	0.30	0.02
K ₂ O	0.01	0.01	nil	0.01	0.01
<u>MISCELLANEOUS</u>					
SO ₃	--	--	0.4	--	--
S ⁼	--	--	--	--	--
C	--	--	--	--	--
<u>LOI</u>	<u>0.2</u>	<u>0.7</u>	<u>3.0</u>	<u>0.20</u>	<u>1.8</u>
<u>TOTAL</u>	99.90	99.27	101.56	99.36	101.33

SUBSTITUTE SHEET

TABLE 1
RAW MATERIALS USED (continued)

Less Pure Raw Materials				
	<u>Kaolin</u>	<u>Blast Furnace Slag</u>	<u>Nepheline Syenite</u>	<u>Talc</u>
ACIDIC OXIDES				
SiO ₂	50.5	35.16	61.3	61.2
AMPHOTERIC OXIDES				
TiO ₂	1.61	0.62	0.003	nil
Al ₂ O ₃	43.6	12.88	23.4	0.7
BASIC OXIDES				
Fe ₂ O ₃	0.80	0.20	0.07	0.85
MnO	--	0.62	--	--
MgO	0.01	16.06	0.05	31.7
CaO	0.04	32.94	0.58	0.19
Na ₂ O	0.06	0.45	9.60	--
K ₂ O	0.02	0.25	4.50	--
MISCELLANEOUS				
SO ₃	--	0.28	--	--
S=	--	1.03	--	--
C	--	0.30	--	--
LOI	<u>2.90</u>	<u>--</u>	<u>0.62</u>	<u>5.0</u>
TOTAL	99.54	100.79	100.12	99.0

SUBSTITUTE SHEET

-18-

Silica Sand: Ottawa Silica - Sil-co-Sil Grade 295
Quick Lime: Mississippi Lime - Pulverized Quick Lime
Calcined Dolomite: Ohio Lime NO. 16 Burnt Dolomitic Lime
Aluminum Oxide: Reynolds Calcined Alumina, RC-23
Magnesium Oxide: Baymag 56 Feed Grade
Kaolin: American Cyanamide Andersonville Kaolin
Blast Furnace Slag: Calumite Morrisville Slag
Nepheline Syenite: Indusmin Grad A400
Talc: Pfizer Grade MP4426

Additives:

Soda Ash: 58.3% Na_2O
Boric Acid: 55.5% B_2O_3
Magnetite Iron Concentrates: 98.5% Iron Oxides
Zircon: 66.2% ZrO_2
Manganese Oxide: 99% MnO_2
Titanium Dioxide: 99% TiO_2
Chromium Oxide: 99.5% Cr_2O_3
Lanthanum Carbonate: Moly Corp.

SUBSTITUTE SHEET

-19-

TABLE 3
COMPOSITION OF FIBERS

TEST NO.	ACIDIC OXIDES			SUB TOTAL	AMPHOTERIC OXIDES				SUB TOTAL
	B ₂ O ₃	SiO ₂	P ₂ O ₅		TiO ₂	Al ₂ O ₃	ZrO ₂		
<u>Composition of Fibers with Al₂O₃ additions (minor constituents only)</u>									
1 to	0.00	--	0.00	--	--	0.01	0.01	0.01	0.02
	--	--	--	--	--	--	--	--	--
<u>Composition of Fibers with B₂O₃ additions</u>									
164	0.32	64.8	--	65.12	--	--	--	--	0.06
165	0.52	63.9	--	64.42	--	--	--	--	1.20
166	0.64	64.6	--	65.24	--	--	--	--	0.06
167	0.82	64.5	--	65.32	--	--	--	--	0.06
168	1.33	64.1	--	65.43	--	--	--	--	0.06
169	1.37	64.1	--	65.47	--	--	--	--	0.06
170	2.22	63.6	--	65.82	--	--	--	--	0.06
171	8.41	59.6	--	68.01	--	--	--	--	0.06
<u>Composition of Fibers with P₂O₅ additions</u>									
2	--	49.6	6.05	55.65	0.06	0.38	0.04	0.04	0.48
<u>Composition of Fibers with TiO₂ additions</u>									
173	--	48.6	--	48.6	10.0	41.4	--	--	51.4
<u>Composition of Fibers with ZrO₂ additions</u>									
174	--	63.5	--	63.5	.01	0.88	0.21	0.21	1.10
175	--	59.2	--	59.2	--	0.33	0.40	0.40	0.73
176	--	59.5	--	59.5	--	0.31	0.42	0.42	0.73

SUBSTITUTE SHEET

-20-

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	BASIC OXIDES										SUB TOTAL
	FeO ₃	MnO	La ₂ O ₃	Cr ₂ O ₃	MgO	Li ₂ O	CaO	BaO	Na ₂ O	K ₂ O	
<u>Composition of Fibers with Al₂O₃ additions (minor constituents only)</u>											
1 to	0.06	0.02	0.00	0.02	--	0.00	--	0.04	0.04	0.01	.19
--	--	--	--	--	--	--	--	--	--	--	--
<u>Composition of Fibers with B₂O₃ additions</u>											
164	--	--	--	--	8.7	--	26.6	--	--	--	35.3
165	--	--	--	--	8.6	--	26.2	--	--	--	34.8
166	--	--	--	--	8.7	--	26.5	--	--	--	35.2
167	--	--	--	--	8.7	--	26.5	--	--	--	35.2
168	--	--	--	--	8.6	--	26.3	--	--	--	34.9
169	--	--	--	--	8.6	--	26.3	--	--	--	34.9
170	--	--	--	--	8.5	--	26.1	--	--	--	34.6
171	--	--	--	--	8.0	--	24.0	--	--	--	32.0
<u>Composition of Fibers with P₂O₅ additions</u>											
2	0.21	0.00	--	0.68	11.15	0.00	31.45	0.00	0.05	0.04	43.58
<u>Composition of Fibers with TiO₂ additions</u>											
173	--	--	--	--	--	--	--	--	--	--	--
<u>Composition of Fibers with ZrO₂ additions</u>											
174	--	--	--	--	0.33	--	35.55	--	.03	.01	35.92
175	--	--	--	--	0.41	--	39.1	--	--	--	39.51
176	--	--	--	--	0.42	--	39.1	--	--	--	39.52

SUBSTITUTE SHEET

-21-

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	MISCELLANEOUS			TOTAL
	SO ₃	Misc.	SUB TOTAL	
<u>Composition of Fibers with Al₂O₃ additions (minor constituents only)</u>				
1 to	.05/ .20	.02 --	.07/ .22	.14 .44
<u>Composition of Fibers with B₂O₃ additions</u>				
164	--	--	--	100.48
165	--	--	--	100.42
166	--	--	--	100.5
167	--	--	--	100.58
168	--	--	--	100.39
169	--	--	--	100.43
170	--	--	--	100.48
171	--	--	--	100.07
<u>Composition of Fibers with P₂O₅ additions</u>				
2	--	0.02	0.02	99.73
<u>Composition of Fibers with TiO₂ additions</u>				
173	--	--	--	100.0
<u>Composition of Fibers with ZrO₂ additions</u>				
174	--	--	--	100.52
175	--	--	--	99.44
176	--	--	--	99.75

SUBSTITUTE SHEET

-22-

TABLE 3
COMPOSITION OF FIBERS

TEST NO.	ACIDIC OXIDES				AMPHOTERIC OXIDES			
	B ₂ O ₃	SiO ₂	P ₂ O ₅	SUB TOTAL	TiO ₂	Al ₂ O ₃	ZrO ₂	SUB TOTAL
Composition of Fibers with ZrO ₂ additions (Cont.)								
177	--	59.7	--	59.7	--	0.34	0.50	0.84
8	--	60.0	--	60.0	--	0.36	0.54	0.90
179	--	59.2	--	59.2	--	0.35	0.58	0.93
180	--	54.3	--	54.3	.01	1.29	0.58	1.88
181	--	59.2	--	59.2	--	0.32	0.83	1.15
182	--	46.85	--	46.85	.02	2.03	0.84	2.89
182(a)	--	59.4	--	59.4	--	0.38	2.31	2.69
183	--	59.05	--	59.05	--	0.30	2.65	2.95
184	--	57.96	--	57.96	--	0.42	3.11	3.53
185	--	57.8	--	57.80	--	0.56	3.12	3.68
186	--	59.05	--	59.05	--	0.38	3.27	3.65
187	--	56.88	--	56.88	--	0.32	3.30	3.62
188	--	57.7	--	57.7	--	0.20	3.30	3.50
189	--	58.19	--	58.19	--	0.39	3.36	3.75
190	--	57.86	--	57.86	--	0.36	3.37	3.73
191	--	58.6	--	58.6	--	0.58	3.67	4.25
192	--	58.4	--	58.4	--	0.65	3.69	4.34
193	--	56.65	--	56.65	.02	3.35	4.50	7.87

SUBSTITUTE SHEET

-23-

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	BASIC OXIDES										SUB TOTAL
	FeO ₃	MnO	La ₂ O ₃	Cr ₂ O ₃	MgO	Li ₂ O	CaO	BaO	Na ₂ O	K ₂ O	
Composition of Fibers with ZrO ₂ additions (Cont.)											
177	--	--	--	--	0.46	--	38.7	--	--	--	39.16
8	--	--	--	--	0.48	--	38.3	--	--	--	38.78
179	--	--	--	--	0.98	--	37.0	--	--	--	37.98
180	.09	.01	--	--	10.20	--	32.75	.01	.04	.02	43.12
181	--	--	--	--	1.13	--	36.6	--	--	--	37.73
182	.08	.01	--	--	20.6	--	29.2	.03	.05	.01	49.98
182(a)	--	--	--	--	2.06	--	34.9	--	--	--	36.96
183	.06	.00	--	.05	3.08	--	34.84	.00	.03	.01	38.07
184	--	--	--	--	3.55	--	35.17	--	--	--	38.72
185	--	--	--	--	3.74	--	34.4	--	--	--	38.14
186	--	--	--	--	2.57	--	36.94	--	--	--	39.51
187	--	--	--	--	4.00	--	36.45	--	--	--	40.45
188	--	--	--	--	3.00	--	36.0	--	--	--	39.0
189	--	--	--	--	3.26	--	35.39	--	--	--	38.65
190	--	--	--	--	3.22	--	35.66	--	--	--	38.88
191	--	--	--	--	2.72	--	33.5	--	--	--	36.22
192	--	--	--	--	2.59	--	33.2	--	--	--	35.79
193	.05	.00	--	.00	3.35	--	31.9	.00	.05	.01	35.36

SUBSTITUTE SHEET

-24-

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	MISCELLANEOUS			TOTAL
	SO ₃	Misc.	SUB TOTAL	
<u>Composition of Fibers with ZrO₂ additions (Cont.)</u>				
177	--	--	--	99.70
8	--	--	--	99.68
179	--	--	--	98.11
180	--	.01	.01	99.31
181	--	--	--	98.08
182	--	.02	.02	99.74
182 (a)	--	--	--	99.05
183	--	.02	.02	100.09
184	--	--	--	100.21
185	--	--	--	99.62
186	--	--	--	102.21
187	--	--	--	100.95
188	--	--	--	100.20
189	--	--	--	100.59
190	--	--	--	100.47
191	--	--	--	99.07
192	--	--	--	98.53
193	--	.01	.01	99.89

SUBSTITUTE SHEET

-25-

TABLE 3
COMPOSITION OF FIBERS

TEST NO.	ACIDIC OXIDES				AMPHOTERIC OXIDES			
	B ₂ O ₃	SiO ₂	P ₂ O ₅	SUB TOTAL	TiO ₂	Al ₂ O ₃	ZrO ₂	SUB TOTAL
Composition of Fibers with FeO ₃ and MnO additions								
194	--	64.9	--	64.9	--	0.06	--	0.06
195	--	49.8	--	49.8	.01	18.0	.01	18.02
196	--	50.4	--	50.4	.03	7.45	.01	7.49
197	--	64.34	--	64.34	--	0.06	--	0.06
198	--	63.70	--	63.70	--	1.20	--	1.20
199	--	63.54	--	63.54	--	1.20	--	1.20
200	--	38.9	--	38.9	.01	6.70	.01	6.72
201	--	64.3	--	64.3	--	0.06	--	0.06
202	--	44.6	--	44.6	.01	0.92	.01	0.94
203	--	63.3	--	63.3	--	1.15	--	1.15
204	--	63.6	--	63.6	--	0.06	--	0.06
205	--	43.8	--	43.8	.01	15.26	.01	15.28
206	--	62.3	--	62.3	--	1.20	--	1.20
207	--	63.3	--	63.3	--	0.06	--	0.06
208	--	43.9	--	43.9	.01	14.3	.01	14.32
209	--	62.0	--	62.0	--	0.06	--	0.06
210	--	60.0	--	60.0	--	2.0	--	2.0
211	--	60.0	--	60.0	--	--	--	--

SUBSTITUTE SHEET

-26-

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	BASIC OXIDES										SUB TOTAL
	FeO ₃	MnO	La ₂ O ₃	Cr ₂ O ₃	MgO	Li ₂ O	CaO	BaO	Na ₂ O	K ₂ O	
Composition of Fibers with FeO ₃ and MnO additions											
194	0.06	--	--	--	8.72	--	26.6	--	--	--	35.38
195	.22	--	--	--	0.2	--	31.5	--	--	--	31.92
196	.48	.04	--	--	15.2	--	26.2	--	.07	.05	42.04
197	.50	--	--	--	7.80	--	26.4	--	--	--	34.7
198	.69	--	--	--	7.73	--	25.30	--	--	--	33.72
199	.72	--	--	--	7.70	--	25.04	--	--	--	33.46
200	.80	--	--	--	16.1	--	37.5	--	--	--	54.40
201	.96	--	--	--	8.6	--	26.4	--	--	--	35.96
202	1.02	--	--	--	18.1	--	32.8	--	--	--	51.92
203	1.61	--	--	--	7.98	--	25.4	--	--	--	34.99
204	1.92	--	--	--	8.6	--	26.1	--	--	--	36.62
205	2.90	.04	--	.14	22.7	--	15.05	--	.10	.01	40.94
206	3.05	--	--	--	8.0	--	25.0	--	--	--	36.05
207	3.45	--	--	--	8.0	--	25.5	--	--	--	36.95
208	3.50	--	--	--	24.4	--	13.7	--	--	--	41.6
209	4.81	--	--	--	8.0	--	25.5	--	--	--	38.31
210	--	8.0	--	--	30.0	--	--	--	--	--	38.0
211	--	20.0	--	--	20.0	--	--	--	--	--	40.0

SUBSTITUTE SHEET

-27-

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	MISCELLANEOUS			TOTAL
	SO ₃	Misc.	SUB TOTAL	
<u>Composition of Fibers with FeO₃ and MnO additions</u>				
194	--	--	--	100.34
195	.05	.02	.07	99.81
196	.05	.02	.07	100.00
197	--	--	--	99.1
198	--	--	--	98.62
199	--	--	--	98.20
200	.05	.02	.07	100.09
201	--	--	--	100.32
202	--	--	--	97.46
203	--	--	--	99.44
204	--	--	--	100.28
205	.05	.08	.13	100.15
206	--	--	--	99.55
207	--	--	--	100.31
208	--	--	--	99.82
209	--	--	--	100.37
210	--	--	--	100.0
211	--	--	--	100.0

INSTITUTE SHEET

TABLE 3
COMPOSITION OF FIBERS

TEST NO.	ACIDIC OXIDES				AMPHOTERIC OXIDES			
	B ₂ O ₃	SiO ₂	P ₂ O ₅	SUB TOTAL	TiO ₂	Al ₂ O ₃	ZrO ₂	SUB TOTAL
<u>Composition of Fibers with La₂O₃ additions</u>								
--	--	58.1	--	58.1	--	0.06	--	0.06
213	--	57.8	--	57.8	--	0.06	--	0.06
214	--	57.5	--	57.5	--	0.06	--	0.06
215	--	56.9	--	56.9	--	0.06	--	0.06
<u>Composition of Fibers with Cr₂O₃ additions</u>								
216	--	62.6	--	62.6	0.01	0.49	0.01	0.51
<u>Composition of Fibers with Na₂O additions</u>								
17	--	64.7	--	64.7	--	0.06	--	0.06
218	--	64.5	--	64.5	--	0.06	--	0.06
219	--	64.4	--	64.4	--	0.06	--	0.06
220	--	63.5	--	63.5	--	1.20	--	1.20
221	--	64.3	--	64.3	--	0.06	--	0.06
222	--	64.2	--	64.2	--	0.06	--	0.06
223	--	64.0	--	64.0	--	0.06	--	0.06
224	--	63.0	--	63.0	--	0.06	--	0.06
225	--	60.3	--	60.3	--	0.06	--	0.06

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	BASIC OXIDES										SUB TOTAL
	FeO ₃	MnO	La ₂ O ₃	Cr ₂ O ₃	MgO	Li ₂ O	CaO	BaO	Na ₂ O	K ₂ O	
<u>Composition of Fibers with La₂O₃ additions</u>											
--	0.16	--	0.00	--	4.60	--	36.71	--	--	--	41.47
213	0.15	--	0.56	--	4.58	--	36.53	--	--	--	41.82
214	0.15	--	0.72	--	4.55	--	36.3	--	--	--	41.72
215	0.15	--	0.92	--	4.51	--	36.0	--	--	--	41.58
<u>Composition of Fibers with Cr₂O₃ additions</u>											
216	0.08	.00	--	0.09	2.30	--	34.10	0.00	0.03	0.01	36.61
<u>Composition of Fibers with Na₂O additions</u>											
17	--	--	--	--	8.7	--	26.6	--	0.28	--	35.58
218	--	--	--	--	8.7	--	26.5	--	0.45	--	35.65
219	--	--	--	--	8.6	--	26.5	--	0.71	--	35.80
220	--	--	--	--	8.5	--	26.1	--	0.87	--	35.70
221	--	--	--	--	8.5	--	26.2	--	0.93	--	35.63
222	--	--	--	--	8.6	--	26.4	--	1.11	--	36.11
223	--	--	--	--	8.6	--	26.3	--	1.40	--	36.3
224	--	--	--	--	8.5	--	25.9	--	2.60	--	37.0
225	--	--	--	--	8.1	--	24.8	--	6.84	--	39.74

-30-

TABLE 3
COMPOSITION OF FIBERS (continued)

TEST NO.	MISCELLANEOUS			TOTAL
	SO ₃	Misc.	SUB TOTAL	
<u>Composition of Fibers with La₂ O₃ additions</u>				
--	--	--	--	99.63
213	--	--	--	99.68
214	--	--	--	99.28
215	--	--	--	98.54
<u>Composition of Fibers with Cr₂O₃ additions</u>				
216	--	--	--	99.72
<u>Composition of Fibers with Na₂O additions</u>				
17	--	--	--	100.34
218	--	--	--	100.21
219	--	--	--	100.26
220	--	--	--	100.40
221	--	--	--	99.99
222	--	--	--	100.37
223	--	--	--	100.36
224	--	--	--	100.06
225	--	--	--	100.1

SUBSTITUTE SHEET

TABLE 3
COMPOSITION OF FIBERS

TEST NO.	ACIDIC OXIDES			AMPHOTERIC OXIDES			SUB TOTAL
	B ₂ O ₃	SiO ₂	P ₂ O ₅	TiO ₂	Al ₂ O ₃	ZrO ₂	
Composition of Conventional Mineral Wools							
226	-	40.0	-	40.0			
	-	39.9	0.02	39.92			
228	-	37.65	0.84	38.49			
229	-	41.75	0.12	41.87			

Composition of Refractory Fibers (Fibers with less than 25% Basic Oxides)

231	-	31.0	-	-	47.5	0.02		47.52
232	-	37.1	-	-	59.2	-		59.2
233	-	50.0	-	-	40.0	-		40.0
234	-	54.0	-	-	46.0	-		46.0
235	-	58.47	1.15	0.98	24.54	0.03		25.55
236	-	52.1	-	1.76	44.4	.23		46.39
237	-	52.0	-	1.71	42.2	2.93		46.84
238	-	49.8	-	1.60	38.3	9.32		49.22
239	-	48.6	-	1.55	36.2	12.3		50.05
240	-	47.8	-	1.50	34.4	15.1		51.00
241	-	46.2	-	1.40	31.0	20.7		53.10
242	-	28	-	19	50	3		72
243	-	64.5	-	-	27.4	-		27.4

SUBSTITUTE SHEET

TABLE 3 (cont'd.)
COMPOSITION OF FIBERS

TEST	BASIC OXIDES										MISCELLANEOUS				
	NO.	FeO ₃	MnO	La ₂ O ₃	Cr ₂ O ₃	MgO	Li ₂ O	CaO	BaO	Na ₂ O	K ₂ O	SUB TOTAL	SO ₃	Misc.	SUB TOTAL
Composition of Conventional Mineral Wools															
226	0.47	0.64	-	0.02	0.02	11.2	0.01	36.5	0.04	0.54	0.55	49.97	0.1	0.59	100.16
	0.35	0.24	-	0.00	0.00	6.05	0.01	38.55	0.12	0.23	0.27	45.82	0.67	0.07	100.47
228	9.7	0.22	-	0.04	0.04	12.95	0.01	23.55	0.07	2.01	0.80	49.35	0.42	0.19	100.69
229	3.75	0.23	-	0.02	0.02	6.45	0.63	27.75	0.03	2.04	0.63	41.53	0.56	0.08	101.14

Composition of Refractory Fibers (Fibers with less than 25% Basic Oxides)

231	-	-	-	-	-	-	-	1.2	-	20.2	-	21.4	-	-	99.92
232	-	-	-	-	-	-	-	0.2	-	3.1	-	3.3	-	-	99.6
233	-	-	-	-	-	-	-	5.6	-	4.4	-	10.0	-	-	100
234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
235	3.70	0.02	-	0.00	0.00	1.44	0.02	5.78	0.54	1.55	1.18	14.23	0.47	0.24	100.11
236	.83	-	-	-	-	0.07	-	0.12	-	.05	.06	1.13	-	-	99.62
237	.77	-	-	-	-	0.07	-	0.12	-	.05	.06	1.07	-	-	99.91
238	.72	-	-	-	-	0.07	-	0.12	-	.05	.06	1.02	-	-	100.04
239	.70	-	-	-	-	0.07	-	0.12	-	.05	.06	1.00	-	-	99.65
240	.68	-	-	-	-	0.07	-	0.12	-	.05	.06	.98	-	-	99.78
241	.63	-	-	-	-	0.07	-	0.12	-	.05	.06	0.93	-	-	100.23
242	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
243	-	-	-	-	-	-	8.4	-	-	-	-	8.4	-	-	100.3

SUBSTITUTE SHEET

- 33 -

TABLE 4
TEST RESULTS ON FIBERS MADE WITH ALUMINA ADDITIONS

COMPOSITION, WT%										
Acidic Oxides		Amphoteric Oxides		Basic Oxides			Total Analytical	5 Hour Saline Extraction		
NO.	SiO ₂	Al ₂ O ₃	Total	CaO	MgO	Total		ppm. Si	Thickness	2 Hour Test**
0 to 1 1/2% Amphoteric Oxides										
1	32	0.2	0.22	39	29	68.1	100.37	*	*	*
2	31.3	0.2	0.22	33.3	35.5	68.9	100.47	*	*	*
3	41.9	0.28	0.30	57.5	0.1	57.7	99.95	80	-	-
4	43.5	0.33	0.35	46.0	10.4	56.5	100.40	58	-	-
5	43.7	0.25	0.27	39.8	16.6	56.5	100.52	46	2.0/1.27	F
6	45.0	0.50	0.52	54.4	0.1	54.6	100.17	75	-	-
7	46.5	0.20	0.22	9.2	45.1	54.4	101.17	*	*	*
8	48.2	0.20	0.22	5.0	47.6	52.7	101.17	*	*	*
9	47.9	0.22	0.24	19.3	33.5	52.9	101.09	50	-	-
10	48.5	0.56	0.58	8.8	43.0	51.9	101.03	51	-	-
11	48.6	0.56	0.58	13.3	38.3	51.7	100.93	46	-	-
12	49.2	0.42	0.44	28.0	22.9	51.0	100.69	67	-	-
13	49.2	0.17	0.19	3.4	48.3	51.8	101.24	*	*	*
14	50.0	0.10	0.12	7.0	43.0	50.1	100.27	56	-	-
15	50.7	0.10	0.12	15.7	33.7	49.5	100.37	60	-	-
16	51.1	0.45	0.47	29.8	19.0	48.9	100.52	65	-	-
17	51.2	0.33	0.35	39.7	9.0	48.8	100.40	51	2.0/2.59	F
18	53.2	0.64	0.66	2.8	44.3	47.2	101.11	56	-	F
19	53.4	0.28	0.30	45.6	0.1	45.8	99.55	77	2.0/1.97	F

* = Not Fiberizable

** P = Pass, F = Failed

SUBSTITUTE SHEET

-34-

EXPERIMENTAL DATA

<u>COMPOSITION, WT%</u>										5 Hour		
Acidic Oxides		Amphoteric Oxides		Basic Oxides				Total		Saline	E-119 Fire Test	
NO.	SiO ₂	Al ₂ O ₃	Total	CaO	MgO	Total		Analytical		Extraction	Thickness	2 Hour Test**
0 to 1 1/2% Amphoteric Oxides										ppm. Si	Density	
20	53.8	0.33	0.35	35.1	10.8	46.0		100.20		83	2.0/1.97	F
21	53.9	0.40	0.42	25.5	20.5	46.1		100.47		68	—	—
22	54.5	1.00	1.02	7.5	36.5	44.1		99.67		30	—	—
23	55.9	0.08	0.10	43.0	0.45	43.55		99.60		51	2.0/1.94	F
24	56.0	0.40	0.42	27.0	17.0	44.1		100.57		69	2.0/2.12	F
25	56.35	0.20	0.24	34.4	8.25	42.75		99.39		70	2.0/1.87	F
26	56.4	0.91	0.93	35.1	7.39	42.59		99.97		47	—	—
27	57.0	1.03	1.05	24.5	17.6	42.2		100.30		46	—	—
28	57.0	1.09	1.11	35.0	6.84	41.94		100.10		40	—	—
29	57.25	0.92	0.94	36.95	3.95	41.1		99.56		56	1.88/2.20	F
30	57.8	0.75	0.78	34.75	6.2	41.05		99.85		—	2.0 / 1.97	F
31	58.1	0.03	0.05	36.7	4.53	41.33		99.53		59	2.0 / 1.91	F
32	58.2	1.08	1.10	35.7	4.79	40.59		99.94		80	2.0 / 1.91	F
33	58.3	0.03	0.05	40.8	0.31	41.21		99.61		49	2.0 / 1.91	F
34	58.4	0.37	0.39	15.3	26.3	41.7		100.54		61	2.0 / 1.91	F
35	58.6	0.09	0.11	35.0	5.36	40.46		99.22		74	2.0 / 1.94	P
36	58.7	0.05	0.07	40.2	0.27	40.57		99.39		58	2.0 / 1.91	F
37	58.5	0.49	0.53	34.4	5.6	40.1		99.32		59	2.0 / 2.01	P
38	58.8	0.41	0.43	35.4	6.2	41.7		100.98		56	—	—

* = Not Fiberizable

** P = Poor, F = Failed

SUBSTITUTE SHEET

-35-

EXPERIMENTAL DATA

COMPOSITION, WT%										5 Hour		
Acidic Oxides		Amphoteric Oxides		Basic Oxides			Total Analytical	Extraction Saline ppm. Si	E-119 Fire Test			
NO.	SiO ₂	Al ₂ O ₃	Total	CaO	MgO	Total			Thickness	2 Hour Test**		
0 to 1 1/2% Amphoteric Oxides												
39	58.9	0.08	0.10	34.2	6.10	40.4	99.45	67	2.0/1.86	P		
40	59.0	0.24	0.26	35.9	3.8	39.9	99.21	49	2.0/1.97	P		
41	59.1	0.09	0.11	40.3	0.43	40.83	100.09	68	2.0/1.90	P		
42	59.2	0.24	0.26	4.7	36.8	41.60	101.11	47	2.5/1.4	F		
43	59.15	0.32	0.34	35.55	4.75	40.40	99.94	60	2.0/1.95	P		
44	59.4	0.04	0.06	29.8	10.7	40.60	100.11	61	2.0/1.92	P		
45	59.5	0.02	0.04	34.2	5.98	40.28	99.87	77	2.0/1.90	P		
46	59.5	0.02	0.04	32.1	8.16	40.36	99.95	73	2.0/1.89	F		
47	59.6	1.43	1.45	22.5	16.8	39.6	100.8	51	2.0/1.88	F		
48	59.6	0.03	0.05	28.7	11.4	40.2	99.9	70	2.0/1.91	P		
50	59.8	0.28	0.30	40.5	0.11	40.71	100.86	30	2.0/2.01	P		
51	59.9	1.48	1.50	25.8	12.9	39.0	100.55	47	2.0/1.98	P		
52	59.9	1.31	1.33	28.1	11.0	39.4	100.78	45	2.0/1.95	P		
53	60.0	1.41	1.43	22.3	16.4	39.0	100.58	41	2.0/1.91	P		
54	60.3	0.17	0.19	32.3	6.36	38.76	99.30	59	2.0/1.89	P		
55	60.4	1.05	1.07	28.5	9.85	38.45	99.97	45	2.0/1.95	P		
56	60.5	1.11	1.13	27.9	10.7	38.9	100.68	36	2.0/1.94	F		
57	60.7	0.93	0.95	28.7	9.47	38.27	99.97	51	2.0/1.93	P		
58	60.8	0.2	0.22	36.	3.	39.10	100.17	56				

* = Not Fiberizable

** P = Poor, F = Failed

SUBSTITUTE SHEET

-36-

EXPERIMENTAL DATA

COMPOSITION, WT%										5 Hour		
Acidic Oxides		Amphoteric Oxides		Basic Oxides			Total Analytical	Saline Extraction ppm. Si	E-119 Fire Test			
NO.	SiO ₂	Al ₂ O ₃	Total	CaO	MgO	Total			Thickness	2 Hour Test**		
0 to 1 1/2% Amphoteric Oxides												
59	61.7	0.02	0.04	32.6	5.19	37.89	99.68	65	2.0/1.97	P		
60	62.4	0.04	0.06	21.7	15.5	37.3	99.81	76	2.0/1.88	P		
61	62.5	0.02	0.04	30.3	6.64	37.04	99.63	66	2.0/1.92	P		
62	62.5	0.03	0.05	29.5	7.70	37.30	99.90	64	2.0/1.82	P		
63	63.1	0.02	0.04	31.1	5.28	36.48	99.67	46	2.0/1.95	P		
64	63.1	1.25	1.27	25.2	10.2	35.5	99.92	19	2.0/1.96	P		
65	63.5	1.49	1.51	24.0	10.9	35.0	100.06	12	2.0/1.91	P		
66	63.8	1.13	1.15	28.4	5.79	34.29	99.29	52	2.0/2.01	P		
67	63.8	1.41	1.43	22.8	11.8	34.7	99.98	17	2.0/1.88	P		
68	64.1	1.23	1.25	30.97	2.60	33.67	99.07	7	2.0/1.88	P		
69	64.1	1.47	1.49	28.6	4.83	33.53	99.17	49	2.0/1.99	P		
70	65.3	0.03	0.05	27.4	6.68	34.18	99.58	37	2.0/1.91	P		
71	65.4	1.15	1.17	3.12	30.1	33.32	99.94	46	2.0/1.88	F		
72	65.6	0.01	0.03	27.4	6.50	34.0	99.68	35	2.0/2.00	P		
73	65.8	0.02	0.04	28.6	5.21	33.91	99.80	44	—	—		
74	65.9	0.03	0.05	21.9	11.8	33.8	99.80	30	2.0/1.87	P		
75	65.9	0.03	0.05	25.8	7.88	33.78	99.78	25	2.0/1.91	P		
76	65.4	1.15	1.17	3.12	30.1	33.23	99.84	46	2.0/1.88	F		

* = Not Fiberizable

** P = Poor, F = Failed

* = Not Fiberizable

** P = Poor, F = Failed

SUBSTITUTE SHEET

-37-

EXPERIMENTAL DATA

<u>COMPOSITION, WT%</u>									
<u>Acidic Oxides</u>		<u>Amphoteric Oxides</u>		<u>Basic Oxides</u>			<u>5 Hour Saline Extraction</u>		
<u>NO.</u>	<u>SiO₂</u>	<u>Al₂O₃</u>	<u>Total</u>	<u>CaO</u>	<u>MgO</u>	<u>Total</u>			
<u>0 to 1 1/2% Amphoteric Oxides (Cont.)</u>							<u>E-119 Fire Test</u>		
							<u>Thickess</u>	<u>Density</u>	<u>Test**</u>
77	66.1	0.59	0.61	4.02	28.7	33.02	50	-	F
78	67.1	-	-	6.43	26.5	33.03	78	2.0/1.89	F
79	67.2	0.02	0.04	8.67	24.0	32.77	84	2.0/2.03	F
80	68.4	-	-	1.6	30.1	31.8	*	*	*
81	68.6	0.25	0.27	29.0	1.09	30.19	18	2.0/2.00	P
82	68.8	-	-	10.2	21.3	31.6	31	-	-
83	68.9	0.03	0.05	18.1	12.7	30.9	30	2.0/2.00	P
84	69.0			7.2	23.8	31.0	18	-	-

1 1/2% to 3% Amphoteric Oxides

85	50.0	2.00	2.02	5.0	43.0	48.1	-	*	*
86	52.6	2.00	2.02	3.8	41.7	45.6	51	2.0/1.88	F
87	56.1	2.41	2.43	30.3	10.6	41.0	39	2.0/1.89	F
88	56.2	1.82	1.84	24.4	17.3	41.8	65	-	-
89	58.1	2.01	2.03	3.83	36.3	40.43	44	2.0/1.99	P
90	58.9	2.26	2.28	36.6	1.4	38.1	18	2.0/1.82	P
91	59.0	2.93	2.95	36.3	1.0	37.4	9	2.0/1.87	P
92	59.4	0.38	2.69	34.9	2.1	37.1	25	2.0/2.06	P
93	59.8	2.54	2.56	27.4	10.0	37.5	11	-	-
94	60.1	1.68	1.70	28.0	9.9	38.0	29	2.0/1.98	P

* = Not Fiberizable

* P = Pass, F = Failed

SUBSTITUTE SHEET

EXPERIMENTAL DATA

COMPOSITION, WT%										5 Hour		
Acidic Oxides		Amphoteric Oxides		Basic Oxides				Total Analytical	Saline Extraction		E-119 Fire Test	
NO.	SiO ₂	Al ₂ O ₃	Total	CaO	MgO	Total	ppm. Si		Thickness	Density	2 Hour Test**	
1 1/2% to 3% Amphoteric Oxides (Cont.)												
95	60.2	2.21	2.23	32.7	4.9	37.7	100.18	50		2.0/2.04		P
96	61.4	2.17	2.19	26.2	10.1	36.4	100.04	18		2.0/1.87		P
97	61.4	1.66	1.68	29.9	6.9	36.9	100.03	61		2.0/1.91		P
98	61.8	2.84	2.86	34.0	0.2	34.3	99.01	51		2.0/1.93		P
99	62.0	2.81	2.83	34.1	0.2	34.4	99.28	55		2.0/1.90		P
100	62.1	2.75	2.77	33.8	0.2	34.1	99.02	13		2.0/1.91		P
101	62.7	1.79	1.81	25.6	9.4	35.1	99.66	18		2.0/1.96		P
102	63.0	2.54	2.56	33.1	0.2	33.4	99.05	37		2.0/1.87		P
103	63.9	1.84	1.86	30.7	2.5	33.3	99.11	38		2.0/1.94		P
104	64.1	1.83	1.85	17.7	16.3	34.3	100.4	12		2.0/1.95		P
105	65.1	2.15	2.17	9.74	23.1	33.15	100.57	17		-		P
106	65.6	1.56	1.58	2.7	29.7	32.5	99.73	33		2.0/1.91		P
107	66.7	1.80	1.82	30.7	0.1	30.9	99.47	2		2.0/1.90		P

3 to 4% Amphoteric Oxides

108	49.8	3.5	3.52	4.98	40.9	46.18	99.65	33	-		-
109	50.3	3.58	3.60	45.0	0.64	45.74	99.69	19	2.0/1.96		F
110	55.1	3.77	3.79	7.89	33.7	41.89	100.93	33	2.0/2.06		P

* = Not Fiberizable

** P = Pass, F = Failed

SUBSTITUTE SHEET

-39-

EXPERIMENTAL DATA

<u>COMPOSITION, WT%</u>									
<u>Acidic Oxides</u>		<u>Amphoteric Oxides</u>		<u>Basic Oxides</u>					
<u>NO.</u>	<u>SiO₂</u>	<u>Al₂O₃</u>	<u>Total</u>	<u>CaO</u>	<u>MgO</u>	<u>Total</u>	<u>Total Analytical</u>	<u>5 Hour Saline Extraction ppm. Si</u>	<u>E-119 Fire Test Thickness Density 2 Hour Test**</u>
<u>3% to 4% Amphoteric Oxides (Cont.)</u>									
111	55.6	0.24	3.66	37.1	4.65	41.85	101.16	-	2.0/2.12 F
112	56.5	0.35	3.65	36.51	4.17	40.78	100.98	-	2.0/1.99 F
113	56.7	3.52	3.54	23.5	16.2	39.8	100.09	19	2.0/1.89 F
114	56.7	3.06	3.08	23.4	16.6	40.28	100.11	40	2.0/4.02 F
115	56.88	0.32	3.64	36.45	4.00	40.45	101.02	51	-
115a	57.5	3.29	3.31	37.7	0.75	38.55	99.41	6	2.0/1.93 F
116	58.1	3.05	3.07	25.6	12.8	38.5	99.72	20	2.0/1.9 F
117	58.2	3.75	3.77	36.4	0.67	37.17	99.19	38	2.0/2.0 F
119	58.80	3.76	3.78	36.7	0.24	37.04	99.67	28	2.0/1.97 F
120	61.2	3.77	3.79	34.0	0.24	34.34	99.38	18	2.0/1.94 P
<u>4 to 6% Amphoteric Oxides</u>									
121	49.7	4.04	4.06	26.4	19.6	46.1	99.91	37	-
122	55.8	5.20	5.22	30.1	9.2	39.4	100.47	7	2.0/1.88 F
123	56.85	5.40	5.41	31.8	5.65	37.55	99.91	4	2.0/1.99 F
124	57.0	4.68	4.70	22.0	15.6	37.7	99.45	32	2.0/2.00 F

** P = Pass, F = Failed

* = Not Fiberizable

SUBSTITUTE SHEET

-40-

EXPERIMENTAL DATA

<u>COMPOSITION, WT%</u>										<u>5 Hour</u>		
<u>Acidic</u>		<u>Amphoteric</u>		<u>Oxides</u>		<u>Basic Oxides</u>		<u>Total</u>		<u>Saline</u>		
<u>NO.</u>	<u>SiO₂</u>	<u>Al₂O₃</u>	<u>Total</u>	<u>CaO</u>	<u>MgO</u>	<u>Total</u>	<u>Analytical</u>	<u>Extraction</u>	<u>ppm. Si</u>	<u>Thickness</u>	<u>Density</u>	<u>Test**</u>
<u>6 to 8% Amphoteric Oxides</u>												
125	39.2	6.90	6.92	38.5	14.0	52.6	98.72	37	-	-	-	-
126	46.9	7.66	7.68	44.8	0.3	45.2	99.83	6	-	2.0/1.97	-	F
127	49.3	6.40	6.42	25.3	18.4	43.8	99.57	19	-	2.0/2.0	-	F
128	50.4	7.45	7.48	26.2	15.2	41.5	99.43	18	-	2.0/3.17	-	F
129	54.7	7.60	7.62	30.7	6.5	37.3	99.67	7	-	2.0/1.98	-	F
130	56.1	6.34	6.36	30.6	6.9	37.6	100.11	4	-	2.0/2.04	-	F
131	57.9	6.7	6.72	5.9	29.7	35.6	100.27	2	-	-	-	-
132	58.5	6.16	6.18	31.2	4.0	35.2	99.93	2	-	2.0/2.01	-	F
133	59.7	7.08	7.10	27.9	5.1	33.1	99.9	2	-	2.0/2.04	-	F
<u>8 to 10% Amphoteric Oxides</u>												
134	38.6	9.3	9.32	38.4	13.7	52.2	100.17	12	-	-	-	-
135	42.8	8.8	9.13	36.7	9.6	46.76	98.69	13	-	-	-	-
136	44.5	8.76	8.78	45.5	0.52	46.12	99.45	3	-	-	-	-
137	52.1	8.9	8.92	23.7	16.2	40.0	101.02	1.2	-	-	-	-
138	52.5	9.67	9.69	33.5	4.21	37.81	100.05	1.0	-	2.0/1.99	-	F
139	53.7	8.7	8.72	22.5	16.3	38.9	101.37	1.7	-	-	-	-
140	56.6	9.2	9.22	23.5	10.9	34.5	100.37	1.2	-	2.0/2.05	-	F

* = Not Fiberizable

** P = Pass, F = Failed

SUBSTITUTE SHEET

EXPERIMENTAL DATA

COMPOSITION, WT%										5 Hour		
Acidic Oxides		Amphoteric Oxides		Basic Oxides			Total Analytical	Extraction ppm. Si	E-119 Fire Test Thickness Density	2 Hour Test**		
No.	SiO ₂	Al ₂ O ₃	Total	CaO	MgO	Total						
10 to 12% Amphoteric Oxides												
141	41.0	10.05	10.07	48.25	0.3	48.70	99.87	6	2.0/2.00	F		
142	51.3	10.9	10.92	37.2	0.2	37.5	99.77	0.8	2.0/2.04	F		
143	52.4	10.7	10.72	23.1	16.1	39.3	102.42	0.7	2.0/2.00	F		
144	52.7	10.2	10.22	22.1	16.0	38.2	101.12	0.5	-	-		
12 to 20% Amphoteric Oxides												
145	41.5	13.0	13.02	44.2	0.5	44.8	99.37	1.2	-	-		
146	49.8	18.0	18.02	31.5	0.2	32.02	99.89	0.5	-	-		
147	55.6	12.9	12.92	13.2	18.4	31.7	100.27	1.8	2.0/2.54	F		
20 to 30% Amphoteric Oxides												
148	36.5	28.4	28.42	34.4	0.3	34.8	99.77	0.6	-	-		
149	40.3	21.5	21.52	37.5	0.3	37.9	99.77	0.8	-	-		
150	42.6	25.7	25.72	31.2	0.3	31.6	99.97	0.6	-	-		
151	48.4	22.4	22.42	16.5	12.6	29.2	100.07	0.5	2.0/2.01	F		
152	59.9	22.8	22.82	3.1	14.0	17.2	99.97	0.7	2.0/2.01	F		
30 to 40% Amphoteric Oxides												
153	45.9	31.3	31.32	5.9	16.7	22.7	99.97	2.3		-		

* = Not Fiberizable

** P = Pass, F = Failed

SUBSTITUTE SHEET

-42-

TABLE 5
FIBERS MADE WITH VARIOUS ADDITIVE CONSTITUENTS

<u>ANALYSES</u>									
5 Hour									
Saline									
Acidic		Amphoteric		Basic		% Additive		E-119 Fire Test	
Oxides		Oxides		Oxides		(Incl.Total)		Thickness	
NO. Oxides		Oxides		Oxides		Total		Density	
NO. Oxides		Oxides		Oxides		Misc.		ppm. Si	
NO. Oxides		Oxides		Oxides		Misc.		ppm. Si	
<u>Fibers with B₂O₃ Additions</u>									
164	65.12	0.06	35.3	-	100.48	0.32% B ₂ O ₃	53	2.0/1.94	P
165	64.42	1.20	34.8	-	100.42	0.52%	20	2.0/1.88	P
166	65.24	0.06	35.2	-	100.5	0.64%	43	2.0/1.89	P
167	65.32	0.06	35.2	-	100.58	0.82%	45	2.0/2.00	P
168	65.43	0.06	34.9	-	100.39	1.33%	47	2.0/1.95	P
169	65.47	0.06	34.9	-	100.43	1.37%	45	2.0/ -	P
170	65.82	0.06	34.6	-	100.48	2.22%	46	2.0/2.02	P
171	68.01	0.06	32.0	-	100.07	8.41%	52	2.0/6.45	P
<u>Fibers with P₂O₅ addition</u>									
172	55.65	0.48	43.58	0.02	99.7	6.06% P ₂ O ₅	71	2.0/1.94	F
<u>Fibers with TiO₂ addition</u>									
173	48.6	51.4	-	-	100.	10% TiO ₂	0.4	2.01/1.94	P

SUBSTITUTE SHEET

-43-

ANALYSES									
		5 Hour							
		Saline		E-119 Fire Test					
		Extraction		Thickess		2 Hour			
		ppm. Si		Density		Test			

SUBSTITUTE SHEET

-44-

ANALYSES									
Test		Amphoteric		Basic		% Additive		5 Hour	
No.	Oxides	Oxides	Oxides	Total	Misc.	(Incl.Total)	Extraction	E-119 Fire Test	
								Thickess	2 Hour Test
Fibers with FeO ₃ additions									
194	64.9	0.06	35.38	-	100.34	0.06% FeO ₃ & MnO	56	2.01/1.88	P
195	49.8	18.02	31.92	0.07	99.81	"	0.5	-	-
196	50.4	7.49	42.04	0.07	100.00	"	18	-	-
197	64.34	0.06	34.7	-	99.1	0.50%	51	2.0/1.91	P
198	63.70	1.20	33.02	-	98.62	0.69%	24	2.0/1.88	F
199	63.54	1.20	33.46	-	98.20	0.72%	35	2.0/2.00	P
200	38.9	6.72	54.40	0.07	100.09	0.80%	17	-	-
201	64.3	0.06	35.96	-	100.32	0.96%	45	2.0/1.88	P
202	44.6	0.94	51.92	-	97.46	1.02%	49	-	-
203	63.3	1.15	34.99	-	99.44	1.61%	12	2.0/1.95	F
204	63.6	0.06	36.62	-	100.15	1.92%	31	2.0/1.91	P
205	43.8	15.28	40.94	0.13	100.02	2.94%	1.3	-	-
206	62.3	1.20	36.05	-	99.55	3.05%	7	2.0/1.98	F
207	63.3	0.06	36.95	-	100.31	3.45%	18	2.0/1.88	F
208	43.9	14.32	41.6	-	99.82	3.50%	2	-	-
209	62.0	0.06	38.31	-	100.37	4.81%	13	2.0/1.98	F
210	60.0	2.0	38.0	-	100.0	8.0%	0.9	2.0/2.00	F
211	60.0	-	40.0	-	100.0	20.0%	0.7	2.0/2.00	F

SUBSTITUTE SHEET

ANALYSES

ANALYSES									
Test No.	Acidic Oxides	Amphoteric Oxides	Basic Oxides	Misc.	Total	% Additive (Incl.Total)	5 Hour		
							Saline Extraction	E-119 Fire Test	2 Hour Test
Fibers with La ₂ O ₃ additions									
212	58.1	0.06	41.47	-	99.63	0.00% La ₂ O ₃	76	2.0/1.97	F
213	57.8	0.06	41.82	-	99.68	0.56% "	69	2.0/1.97	F
214	57.5	0.06	41.72	-	99.28	0.72% "	78	2.0/1.98	F
215	56.9	0.06	41.58	-	99.54	0.92% "	70	2.0/1.98	F
Fibers with Cr ₂ O ₃ additions									
216	62.6	0.51	36.61	-	99.72	0.09% Cr ₂ O ₃	28	2.0/2.16	P
Fibers with Na ₂ O additions									
217	64.7	0.06	35.58	-	100.34	0.28% Na ₂ O	45	2.0/1.91	P
218	64.5	0.06	35.68	-	100.21	0.45% "	57	2.0/1.97	P
219	64.4	0.06	35.80	-	100.26	0.71% "	54	2.0/1.97	P
220	63.5	1.20	35.70	-	100.40	0.87% "	30	2.0/1.90	P
221	64.3	0.06	35.63	-	99.99	0.93% "	51	2.0/1.90	P
222	64.2	0.06	36.11	-	100.37	1.11% "	57	2.0/1.99	P
223	64.0	0.06	36.3	-	100.36	1.40% "	43	2.0/1.99	P
224	63.0	0.06	37.0	-	100.06	2.60% "	50	2.0/2.16	F
225	60.3	0.06	39.74	-	100.1	6.84% "	70	2.0/1.87	F

-45-

SUBSTITUTE SHEET

ANALYSES

<u>ANALYSES</u>										
Test No.	Acidic Oxides	Amphoteric Oxides	Basic Oxides	Misc.	Total	% Additive (Incl.Total)	5 Hour		E-119 Fire Test	
							Saline Extraction ppm. Si	Thickenss	Density	2 Hour Test
<u>Conventional Mineral Wool Fibers</u>										
226	40.0	9.50	49.97	0.69	100.16	-	7		2.0/3.50	F
227	39.92	13.99	45.82	0.74	100.47	-	1.2		2.0/5.23	F
228	38.49	12.24	49.35	0.61	100.69	-	0.6		2.0/3.42	F
229	41.87	17.10	41.53	0.64	101.14	-	1.0		2.0/3.86	F

Refractory Fibers - (Fibers with less than 25% Basic Oxides)

231	31.0	47.52	21.4	-	99.92	-	-	2	2.0/2.10		F
232	37.1	59.2	3.3	-	99.6	-	-	0.6	2.0/5.38		F
233	50.0	40.0	10.0	-	100	-	-	0.8	2.0/2.00		P
234	54.0	46.0	-	-	100	-	-	0.3	2.0/2.00		P
235	59.62	25.55	14.23	0.7	100.11	-	-	0.3	2.0/2.00		P
236	52.1	46.39	1.13	-	99.62	-	-	1.0	-		-
237	52.0	46.84	1.07	-	99.91	-	-	0.4	-		-
238	49.8	49.22	1.02	-	100.04	-	-	0.3	-		-
239	48.6	50.05	1.00	-	99.65	-	-	0.4	-		-
240	47.8	51.00	0.98	-	99.78	-	-	0.3	-		-
241	46.2	53.10	0.93	-	100.23	-	-	0.4	-		-
242	28	72	-	-	100	-	-	0.5	-		-
243	64.5	27.4	8.4	-	100.3	-	-	0.8	2.0/1.85		F

SUBSTITUTE SHEET

-47-

TABLE 6

CONTINUOUS SERVICE TEMPERATURE
FOR CONSTANT $\text{SiO}_2/\text{CaO}/\text{MgO}$ RATIOS

$\text{SiO}_2/\text{CaO}/\text{MgO}$ Ratio	0	5	10	20	30
	Continuous Service Temperature for max 5% shrinkage °F				
50/50/0	1480	1480	1470	1420	1550
50/40/10	1440	1430	1420	1400	1520
50/30/10	1400	1380	1370	1350	1480
60/40/0	1500	1460	1460	1460	1600
60/30/10	1430	1420	1400	1410	1520
60/20/20	1380	1370	1360	1350	1500

SUBSTITUTE SHEET

-48-

Reasonable modifications and variations are possible from the foregoing disclosure without departing from either the spirit or scope of the invention as defined in the claims.

SUBSTITUTE SHEET

-49-

CLAIMS

1. A process for decomposing a silica-containing fiber comprising the steps of:

1. providing an inorganic fiber prepared from a composition consisting essentially of:

(a) 0.06-10 wt% of a material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 35-70 wt% SiO_2 ;

(c) 0-50 wt% MgO ; and

(d) the remainder consisting essentially of CaO , the total being 100% by weight;

2. subjecting the silica-containing fiber to a physiological saline fluid; and

3. extracting the silica at a rate of at least 5 parts per million (ppm) of silicon in 5 hours, thereby decomposing the silica-containing fiber.

2. The process of Claim 1 wherein the composition of subsection 1(a) ranges from 0.06-5 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof.

3. The process of Claim 1 wherein the composition of subsection 1(c) ranges from 0.25-50 wt% MgO .

4. The process of Claim 1 wherein the composition consists essentially of:

SUBSTITUTE SHEET

-50-

(a) 0.06-1.5 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 40-70 wt% SiO_2 ;

(c) 0-50 wt% MgO ; and

(d) the remainder consisting essentially of CaO , the total being 100% by weight.

5
10 5. The process of Claim 4 wherein the composition in subsection 1(c) ranges from 0.25-50 wt% MgO .

6. The process of Claim 1 wherein the composition consists essentially of:

15 (a) 1.5-3 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 40-66 wt% SiO_2 ;

(c) 0-50 wt% MgO ; and

20 (d) the remainder consisting essentially of CaO , the total being 100% by weight.

7. The process of Claim 1 wherein the composition of subsection 1(c) ranges from 0.25-50 wt% MgO .

25 8. The process of Claim 1 wherein the composition consists essentially of:

(a) 3-4 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 40-63 wt% SiO_2 ;

(c) 0-50 wt% MgO ; and

SUBSTITUTE SHEET

-51-

(d) the remainder consisting essentially of CaO, the total being 100% by weight.

5 9. The process of Claim 8 wherein the composition of subsection 1(c) ranges from 0.25-50 wt% MgO.

10 10. The process of Claim 1 wherein the composition consists essentially of:

- 10 (a) 4-6 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;
- (b) 40-60 wt% SiO_2 ;
- (c) 0-25 wt% MgO; and
- 15 (d) the remainder consisting essentially of CaO, the total being 100% by weight.

 11. The process of Claim 10 wherein the composition of subsection 1(c) ranges from 0.25-25 wt% MgO.

20 12. The process of Claim 1 wherein the composition consists essentially of:

- (a) 6-8 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;
- (b) 35-54 wt% SiO_2 ;
- (c) 0-25 wt% MgO; and
- 25 (d) the remainder consisting essentially of CaO, the total being 100% by weight.

30 13. The process of Claim 12 wherein the composition of subsection 1(c) ranges from 0.25-25 wt% MgO.

SUBSTITUTE SHEET

-52-

14. The process of Claim 1 wherein the composition consists essentially of:

(a) 8-10 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 35-54 wt% SiO_2 ;

(c) 0-20 wt% MgO ; and

(d) the remainder consisting essentially of CaO , the total being 100% by weight.

15. The process of Claim 14 wherein the composition of subsection 1(c) ranges from 0.25-20 wt% MgO .

16. The process of Claim 1 wherein the fiber has a diameter of less than 3.5 microns.

17. The process of Claim 1 wherein the silicon extraction rate is at least 20 ppm, the Al_2O_3 content is about 0.06-7 wt%, and the SiO_2 content is about 40-66 wt%.

18. The process of Claim 1 wherein the silicon extraction rate is at least about 50 ppm, the Al_2O_3 content is about 0.06-3 wt%, and the SiO_2 content is about 40-60 wt%.

19. The process of Claim 1 wherein the silicon extraction rate is at least about 50 ppm, the Al_2O_3 content is about 0.06-0.75 wt%, and the SiO_2 content is about 40-60 wt%.

20. A process of protecting a structural wall from fire comprising the steps of:

SUBSTITUTE SHEET

-53-

1. providing a fiber blanket having a bulk density in the range of about 1.5 to about 3 lbs. per cubic foot (pcf); wherein the fiber blanket has the ability to pass ASTM E-119 two-hour fire test; the fibers in the blanket have a diameter less than about 3.5 microns; and the fiber is an inorganic fiber prepared from a composition consisting essentially of:

(a) 0-7 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 58-70 wt% SiO_2

(c) 0-21 wt% MgO ;

(d) 0-2 wt% alkali metal oxide; and

(e) the remainder consisting essentially of CaO , the total being 100% by weight; and

2. placing the blanket next to the wall, and thereby protecting the wall from fire.

21. The process of Claim 20 wherein the composition of subsection 1(a) ranges from 0.06-7 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof.

22. The process of Claim 20 wherein the composition of subsection 1(c) ranges from 0.25-21 wt% MgO .

23. The process of Claim 20 wherein the composition consists essentially of:

(a) 0.06-3.0 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 58.5-70 wt% SiO_2 ;

SUBSTITUTE SHEET

-54-

- (c) 0-21 wt% MgO;
(d) 0-2 wt% alkali metal oxide; and
(e) the remainder consisting essentially of CaO, the total being 100% by weight.

5

24. The process of Claim 20 wherein the composition of subsection 1(c) ranges from 0.25-21 wt% MgO.

10 25. The process of Claim 20 wherein the composition consists essentially of:

- (a) from about 3 wt% up to and including 4 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;
(b) 58-63 wt% SiO_2 ;
(c) 0-8 wt% MgO;
(d) 0-2 wt% alkali metal oxide; and
(e) the remainder consisting essentially of CaO, the total being 100% by weight.

15

20 26. The process of Claim 25 wherein the composition in subsection 1(c) ranges from 0.25-8 wt% MgO.

25 27. The process of Claim 25 wherein the composition consists essentially of:

- (a) from about 4 wt% up to and including 6 wt% of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;
(b) 58-61 wt% SiO_2 ;
(c) 0-7 wt% MgO;
(d) 0-2 wt% alkali metal oxide; and

30

SUBSTITUTE SHEET

-55-

(e) the remainder consisting essentially of CaO , the total being 100% by weight.

28. The process of Claim 25 wherein the composition of subsection 1(c) ranges from 0.25-7 wt% MgO .

29. An inorganic fiber having an average fiber diameter of less than about 3.5 microns, a silicon extraction rate greater than about 0.02 wt% Si/day in a physiological saline solution and having a composition consisting essentially of about:

(a) 0.06-5.0 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 35-70 wt% SiO_2 ;

(c) 0-50 wt% MgO ; and

(d) the remainder consisting essentially of CaO , the total being 100 wt%.

30. An inorganic fiber having a silicon extraction of at least about 10 ppm over a 5 hour period in physiological saline solution and having a composition consisting essentially of about:

(a) 0.06-1.5 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 40-70 wt% SiO_2 ;

(c) 0-50 wt% MgO ; and

(d) the remainder consisting essentially of CaO , the total being 100 wt%.

SUBSTITUTE SHEET

-56-

31. An inorganic fiber according to Claim 30 having a silicon extraction of at least about 20 ppm, an average fiber diameter of less than about 3.5 microns, and having an SiO_2 content of about 40-66 wt%.

5 32. An inorganic fiber according to Claim 30 having a silicon extraction of at least about 50 ppm and having an SiO_2 content of about 40-60 wt% and a MgO content of about 0.25-25 wt%.

10 33. An inorganic fiber having a silicon extraction of at least about 10 ppm over a 5 hour period in physiological saline solutions and having a composition consisting essentially of about:

15 (a) 1.5-3 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 40-66 wt% SiO_2 ;

(c) 0-50 wt% MgO; and

20 (d) the remainder consisting essentially of CaO, the total being 100 wt%.

34. An inorganic fiber according to Claim 33 having a silicon extraction of at least about 20 ppm, an average fiber diameter of less than about 3.5 microns, and an MgO content of from about .25-50 wt%.

25 35. An inorganic fiber according to Claim 33 having a silicon extraction of at least about 50 ppm, an SiO_2 content of from about 40-54 wt%, and an MgO content of from about 0.25-18 wt%.

30 36. An inorganic fiber having a silicon extraction of at least about 10 ppm over a 5 hour period

SUBSTITUTE SHEET

-57-

in physiological saline solutions and having a composition consisting essentially of about:

- 5 (a) 3-4 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;
- (b) 40-63 wt% SiO_2 ;
- (c) 0-50 wt% MgO ; and
- 10 (d) the remainder consisting essentially of CaO , the total being 100 wt%.

37. An inorganic fiber according to Claim 36 having a silicon extraction of at least about 20 ppm, an average fiber diameter of less than about 3.5 microns, and a SiO_2 content from about 40-58 wt%.

15 38. An inorganic fiber according to Claim 37 having a silicon extraction of at least about 50 ppm and an SiO_2 content of from about 40-52 wt% and a MgO content of from about .25-18 wt%.

20 39. An inorganic fiber having a silicon extraction of at least about 10 ppm over a 5 hour time period in a physiological saline solution and having a composition consisting essentially of about:

- 25 (a) 4-6 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;
- (b) 40-59 wt% SiO_2 ;
- (c) 0-46 wt% MgO ; and
- 30 (d) the remainder consisting essentially of CaO , the total being 100 wt%.

SUBSTITUTE SHEET

-58-

40. An inorganic fiber according to Claim 39 having a silicon extraction of at least about 20 ppm, an average fiber diameter of less than about 3.5 microns, and an SiO_2 content from about 40-58 wt%.

5 41. An inorganic fiber having a diameter of less than about 3.5 microns and which passes the ASTM E-119 two hour fire test when processed into a fiber blanket having a bulk density in the range of about 1.5 to 3 pcf, said inorganic fiber having a composition
10 consisting essentially of:

(a) .06-7 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

15 (b) 58-70 wt% SiO_2 ;

(c) 0-21 wt% MgO ;

(d) 0.1-2 wt% alkali metal oxide;

and

(e) the remainder consisting essentially of CaO , the total being 100 wt%;
20 wherein the amount of alumina + zirconia is less than 6 wt% and the amount of iron oxides or alumina + iron oxides is less than 2 wt%.

25 42. An inorganic fiber according to Claim 41 having a composition consisting essentially of about:

(a) .06-1.5 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof; and

30 (b) 58.5-70 wt% SiO_2 .

SUBSTITUTE SHEET

-59-

43. An inorganic fiber according to Claim 42 having a silicon extraction of at least about 10 ppm over a 5 hour period in physiological saline solutions.

5 44. An inorganic fiber according to Claim 41 having a composition consisting essentially of about:

(a) greater than 1.5 wt% up to and including 3 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof; and

10 (b) 58.5-66 wt% SiO_2 .

45. An inorganic fiber according to Claim 44 having a silicon extraction of at least about 10 ppm over a 5 hour period in a physiological saline solution.

15 46. An inorganic fiber according to Claim 41 having a composition consisting essentially of about:

(a) greater than 3 wt% up to and including 4 wt% material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

20 (b) 58-63 wt% SiO_2 ;

(c) .25-8 wt% MgO ;

(d) .1-2 wt% alkali metal oxide;

and

25 (e) the remainder consisting essentially of CaO , the total being 100 wt%.

47. An inorganic fiber according to Claim 46 having a silicon extraction of at least about 10 ppm over a 5 hour period in physiological saline solutions.

SUBSTITUTE SHEET

-60-

48. An inorganic fiber according to Claim 41 having a composition consisting essentially of about:

(a) greater than 4 wt% up to and including 6 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 58-59 wt% SiO_2 ;

(c) .25-7 wt% MgO ;

(d) .1-2 wt% alkali metal oxide;

and

(e) the remainder consisting essentially of CaO , the total being 100 wt%.

49. An inorganic fiber according to Claim 48 having a silicon extraction of at least about 10 ppm over a 5 hour period in physiological saline solutions.

50. An inorganic fiber having a silicon extraction of greater than about 0.02 wt% Si/day in a physiological saline solution, a continuous service temperature above about 1450°F and having a composition consisting essentially of about:

(a) .06-5 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;

(b) 40-70 wt% SiO_2 ;

(c) 0-6 wt% MgO ; and

(d) the remainder comprising essentially of CaO , the total being 100 wt%.

51. The fiber of Claim 50 wherein the composition of subsection (c) has an amount of 0.25-6 wt% MgO .

SUBSTITUTE SHEET

-61-

52. An inorganic fiber having a silicon extraction of greater than about 0.02 wt% Si/day in a physiological saline solution, having a continuous service temperature above about 1500°F and having a composition consisting essentially of about:

- (a) .06-1.5 wt% of material selected from the group consisting of Al_2O_3 , ZrO_2 , TiO_2 , B_2O_3 , iron oxides and mixtures thereof;
- (b) 60-70 wt% SiO_2 ;
- (c) 0-1 wt% MgO ; and
- (d) the remainder consisting essentially of CaO , the total being 100 wt%.

53. The fiber of Claim 52 wherein the composition of subsection (c) has an amount 0.25-1 wt% MgO .

54. An inorganic fiber according to Claims 1 or 29 made from pure oxidic raw materials.

55. An inorganic fiber according to Claim 1 or 29 or 41 in which at least a portion of the raw materials is selected from a group consisting of talc, metallurgical slags, siliceous rocks, kaolin, and mixtures thereof.

56. An inorganic fiber having a composition consisting essentially of about:

- (a) 8.0-9.3 wt% Al_2O_3 ;
- (b) 39-52 wt% SiO_2 ;
- (c) 22-38 wt% CaO ; and
- (d) 7-14 wt% MgO , the total being 100 wt% and having a silica extraction in a saline solution of at least about 5 ppm over a 5 hour period.

SUBSTITUTE SHEET

-62-

57. An inorganic fiber composition having a composition consisting essentially of about:

(a) 49-61 wt% SiO_2 ;

(b) 10-36 wt% CaO ; and

(c) 3-23 wt% MgO , the total being 100 wt% and having a SiO_2 extraction in a saline solution of between about 24-67 ppm over a 5 hour period.

5

SUBSTITUTE SHEET